EXPERIMENTING WITH QUALITY DATA NEW DIMENSIONS OF STATISTICAL EDUCATION IN INDUSTRIAL PROCESS CONTROL

Hans-Joachim Mittag, University of Hagen, Germany

Computer-based training may open fascinating new dimensions for learning. This statement is examplified by means of an innovative course on control charts. The teachware aims at improving the efficiency of statistical education at Universities or Polytechnic Schools as well as at supporting graduated statistical training on the job for people in the workplace. It emphasizes learning by experimenting with simulated quality data and by applying interactive graphical procedures.

The course has a modular structure and possesses easy-to-handle navigation tools. Starting from the menu page the user may call for an individual learning path adapted to his specified previous knowledge. During course work the learner has comfortable hypertext functionalities at his disposal. He may, for example, fade in definitions of statistical terms, jump into selected course extracts or release interactive simulation experiments and immediately display their results.

INTRODUCTION

Due to the breakneck speed of progress in computer technology and the closely associated progress in teachware didactic, academic training as well as further education in practice faces a new era. Especially for statistical education the use of modern interactive teachware may unfold fascinating vistas of learning and understanding of basic concepts. Hence, in the future, computer-based statistical training will play an important role as a complement to traditional forms of teaching and learning. It offers obvious economic benefits and didactic advantages inaccessible via print media or classroom teaching.

In the recent past computer-based instruction had a rather bad reputation because the first software programs for self-controlled learning were very inflexible and non-interactive. In a classical language laboratory, for example, the learner was confronted with a linear learning path without having any chance to adapt the path to individual needs. Nowadays the disadvantages of the early teachware are fast disappearing. Up-to-date teachware, namely for statistics, is characterized by the following features:

- *Decentralized and autonomous learning*

  In an analogous way to learning via print media, the learner has the option to choose his starting point, duration and place of learning.

- *Individualized learning*

  The modular structure of up-to-date teachware offers the option to define the learning path as a function of previous knowledge.

- *Interactive learning*

  Computer-based training in Statistics now offers the opportunity to explore statistical concepts by playing with real-world or artificial data and by releasing interactive simulation experiments.

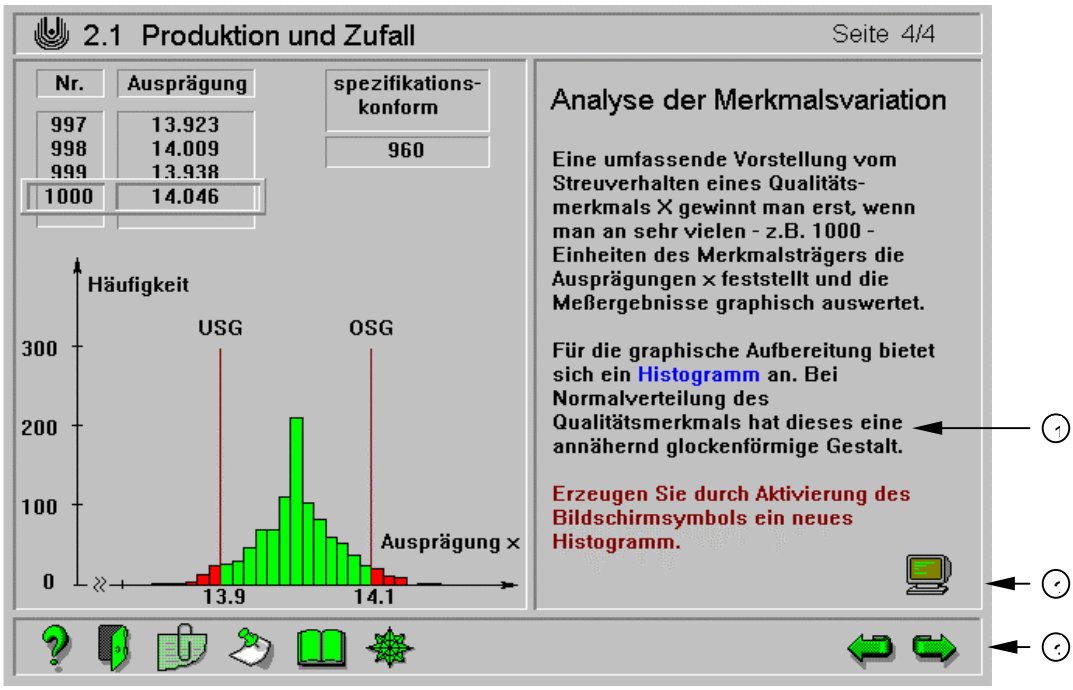
- *Learning by means of visualisation*

  It is now possible to study effects by means of dynamic animations or to immediately display the graphical results of simulation experiments that are under one's own control. Visualisations of this type increase the intensity and efficiency of statistical education.

A TEACHERWARE PROTOTYPE DEALING WITH CONTROL CHARTS

In order to demonstrate the potential of modern statistical teachware, the University of Hagen, Germany, developed a teachware prototype in German dealing with statistical process control by means of control charts. The software was designed for simultaneous use in academic environments as well as for further education in industry. The topic "control charts" seemed particularly suitable for illustrating basic statistical concepts (random variables and their distributions, hypothesis testing, estimation of parameters) and the use of simulation as a tool of statistical research. The course design aimed at accentuating those advantages of modern teachware which are basically inaccessible via traditional teaching methods. The course has a modular structure and possesses easy-to-handle navigation tools in addition to the usual hypertext functionality. Starting from the menu page the program user could specify his previous knowledge in statistics and in quality management and ask for an individual learning path. During course work the learner may fade in detailed explanations and definitions or grasp basic ideas by releasing simulation experiments. Figure 1 shows an experiment related to repeatedly generating data from a given normal distribution and graphically displaying the results by means of a histogram.

Figure 1. Example of a simple simulation experiment



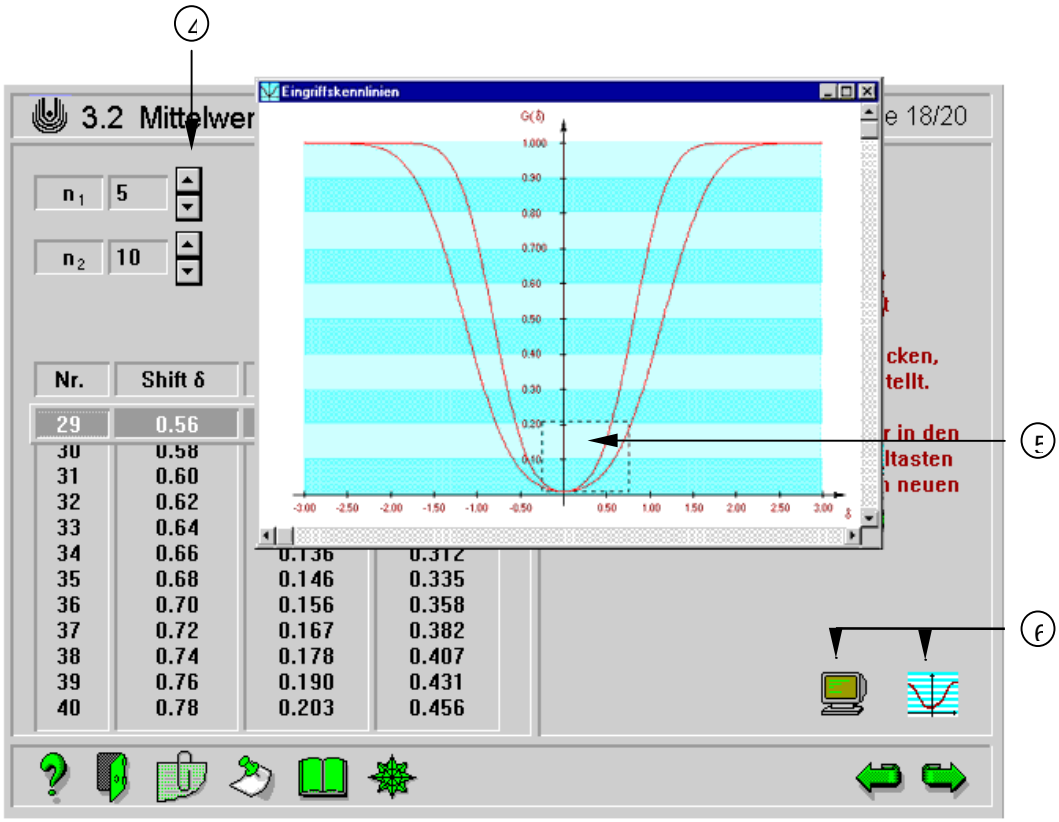
1 Hypertext functionality (jump function leading to a glossary)

2 Release of simulation experiment

3 Course navigation tools

The course contains numerous interactive algorithms and graphical procedures. Figure 2 shows such a course element. The learner may here specify the design parameters of two Shewhart-type control charts and immediately calculate and graphically display the power functions relating to these charts. A zoom option is offered for magnifying details of the graph.

Figure 2. Determination of power curves for Shewhart-type control charts (two-sided mean charts)



4 Buttons for choosing control chart design parameters

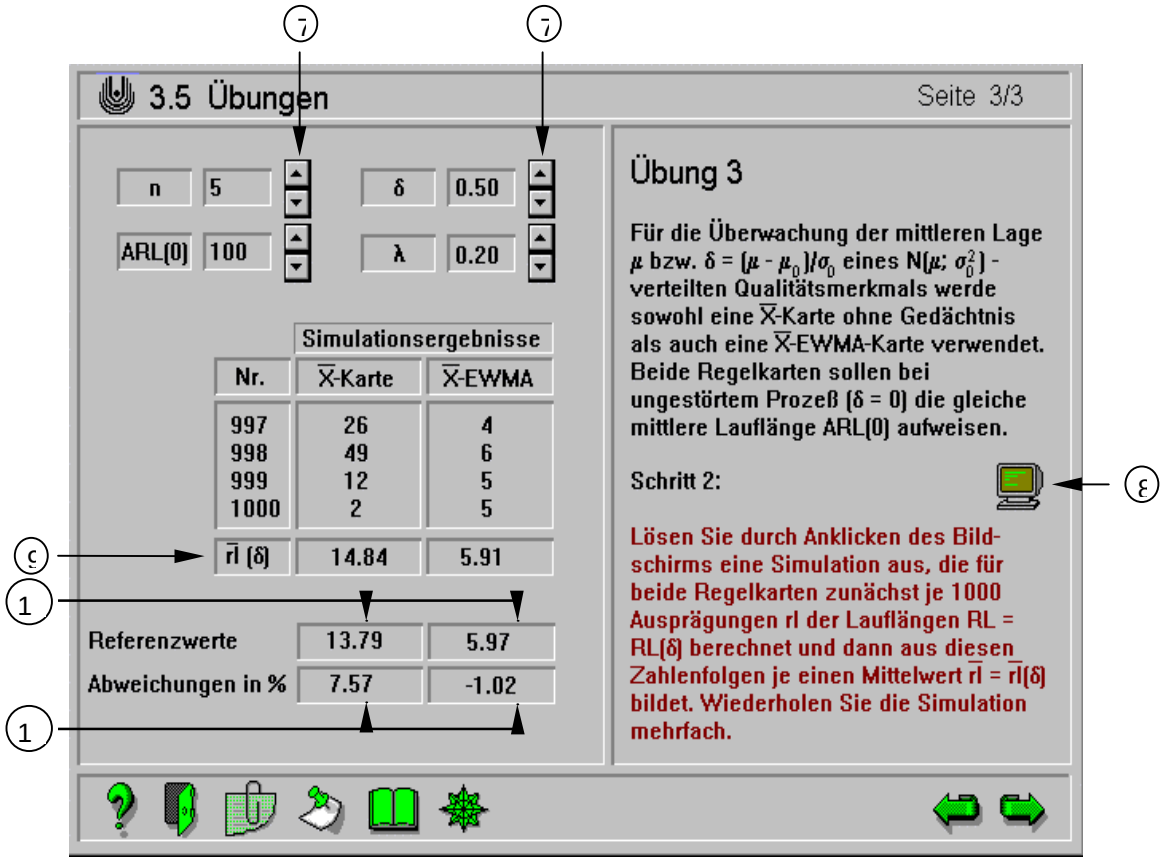
5 Zoom area

6 Release of operations for calculating and graphically displaying power functions

The teachware not only aims at trying out new ways of imparting knowledge in statistical process control but also at accelerating the transmission of modern approaches in this field from theory to industrial practice. For this reason it also covers exponentially weighted moverage charts (EWMA charts) as an alternative to the well established Shewhart charts. A performance comparison of both control chart types by means of their average run length (ARL) functions can be based either on numerically calculated approximate ARL values - see Crowder (1987a, b) for details - or on ARL values estimated by simulation. Figure 3 shows a course extract dealing with the ARL comparison of a Shewhart-type and an EWMA-type mean chart. The learner can specify the design parameters of both charts (sample size, in-control ARL, for the EWMA chart a weight parameter defining the chart “memory”) and a process parameter (standardized

shift) before releasing a simulation run. The experiment leads to a simulated ARL value which is immediately compared with its analytically calculated counterpart. By repeatedly carrying out the experiment the teachware user learns both the performance difference of the control charts involved and the power of simulation studies for statistical research.

Figure 3. Interactive simulation experiment for comparing the performance of a Shewhart-type and an EWMA-type control chart (two-sided mean charts)



7 Scroll buttons for choosing design and process parameters

8 Release of the simulation experiment

9 Simulation results

10 Numerical results as a benchmark

11 Difference between simulated and numerical results in per cent

The German Foundation for Industrial Research considered the teachware described above as a software prototype especially suitable for further education in

industry and recognized its innovative potential by conferring in November 1997 an award on it, the “Initiativpreis 1997”.

OUTLOOK ON FUTURE DEVELOPMENTS

Applying the terminology of Biehler (1997), the interactive teachware on control charts described above represents a closed microworld with elements of a “Monte Carlo workbench”. The software offers a guided discovery approach to basic concepts of statistical process control by combining exploratory visualisations, interactive graphical procedures and simulation experiments. As the attribute “closed” indicates, the software is not open to user- selected data sets and is not linked with the growing Internet.

Future statistical teachware projects will aim at creating really open net-operating or net-linked educational software. In fall 1997, the government of the German Federal State of North Rhine Westphalia has launched a multimedia educational network program for universities (“Universitätsverbund MultiMedia NRW”). Within this framework the University of Hagen will develop, in German, an introductory multimedia course “Statistics”. This teachware will be highly interactive and open to the real world via Internet links. It will be a module within a growing worldwide system of virtual statistical education. The University of Hagen is looking for partners who are interested in translating the forthcoming multimedia teachware and in adapting it to their specific needs.

REFERENCES

Biehler, R. (1997). Software for Learning and for Doing Statistics, *International Statistical Review* 65, 167-189.

Crowder, S. V. (1987a). A Simple Method for Studying Run Length Distributions of Exponentially Weighted Moving Average Charts, *Technometrics* 29, 401-407.

Crowder, S. V. (1987b). Average Run Length of Exponentially Weighted Moving Average Control Charts, *Journal of Quality Technology* 19, 161-164.